

## IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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In re Patent Application of:  
Robert A August et al.

Application No.: 10/693,847

Confirmation No.: 7110

Filed: October 20, 2003

Art Unit: 2878

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For: Neutron detection device and method of  
manufacture

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Examiner: D. Malevic

## DECLARATION UNDER 37 CFR 1.132

I, Robert R. Whitlock, having been advised of the penalties for perjury, declare as follows:

1. I am a citizen and resident of the United States of America.
2. I was working in the capacity of Research Scientist for the Naval Research Laboratory, (NRL) Washington, DC, the assignee of the above-identified application, at the time of the invention.
3. I am a co-inventor of the above-identified application, U.S. Application Serial No. 10/693,847 for NEUTRON DETECTION DEVICE AND METHOD OF MANUFACTURE, which names Robert August, Harold Hughes, and Patrick McMarr as the co-inventors.
4. I have read the Hossain Patent No. 6075261, and present the following discussion of the reference in order to provide understanding of the present invention and the differences between Hossain and U.S. Patent Application No. 10/693,847.

5. In the neutron conversion process, the neutron conversion layer converts incident neutrons into particles that are detectable by the charge-sensitive elements. In this process, a single neutron is absorbed by an atomic nucleus of the neutron conversion layer, and that nucleus undergoes a reaction producing emitted particles, for example an ionic particle such as an alpha particle or an ionized atomic nucleus. For a given composition of neutron conversion layer, the available neutron-induced nuclear reactions are known in the scientific literature, as are the identity and energy of the emitted product particles. A resultant emitted particle may travel from the neutron conversion layer toward the active semiconductor layer. Ionic particles traveling through matter, such as the neutron conversion layer material or the active semiconductor material or any intervening material, liberate charges and deposit energy in the matter along their travel path. This loss of energy causes them to slow down, and eventually lose their remaining energy and stop within a typical distance called the range. The ranges of ions in materials of interest depend on their energy and on the material being penetrated, and these are known in combination and published, for example, in *The Stopping and Range of Ions in Solids*, J. F. Ziegler, IIT Press, 2002, or calculated by the Ziegler SRIM code. Charges liberated by this process that reach the charge-sensitive elements form the basis for neutron detection. Close proximity for the present invention has been disclosed as being no greater than the range of neutron reactant particles emitted from said neutron conversion layer penetrating to the active semiconductor layer (see para. [0030]). This range is the Ziegler's range for the initially produced product ionic particle passing through the materials present. For the purpose of determining this separation distance, the charge-sensitive element is taken to extend only so far

as it is sensitive to liberated charges. The definition of close proximity is the same, whether the conversion layer is placed above or below the charge-sensitive elements.

6. Owing to the statistical nature of the slowing down process, a few particles will penetrate farther than the range. Thus, a neutron detector with neutron conversion layer placed outside of close proximity, as is the case in Hossain, may retain a diminished function at reduced detection efficiency, with greater reductions for greater separation distances. However, such a device will not operate as an effective and reliable neutron detection device.
7. Hossain provides scant guidance on neutron-reactant layer thicknesses. "The thickness of the neutron-reactant material is selected to allow penetration of some of the emitted particles, such as 4-alpha, into the underlying memory cell. Suitable thickness range from about 2000 to 5000 angstroms for many applications." (Column 3, line 50). Hossain does not provide any method for determining optimal thickness for the neutron-reactant material. In actuality, this varies drastically with composition and isotope. The thickness numbers provided by Hossain would be sub-optimal for solid boron-10 by a factor of about 5 to 12, either factor being a critical variation. Hossain's determination of thickness apparently only considers escape distance for the product particle (alpha). He does not include penetration depth of the reactant (neutron). In practical application, optimal thickness must take both into account. Hossain's teaching on thickness of neutron-reactant layers is incomplete, does not account for neutron penetration ranges, and does not adequately account for nuclear product (e.g., alpha) penetration ranges.
8. Hossain provides the following scant guidance on insulating layer thicknesses. Hossain discloses an insulating layer 119 with reference to Figure 1A. Although he does not include

the indicium 119 on the figure, the description (Column 2, line 61) makes clear that the insulating layer 119 is above and around the gate structure 109. More particularly Hossain incompletely and inadequately discloses the insulating layer. "Formed over the gate structure 109 may, for example, be an insulating layer 119, such as an oxide" (Col. 2, Line 59). The thickness of the insulating layer 119 is not disclosed, and is not identified as an important parameter. Assuming that the thickness of the insulating layer 119 is of on the scale of thicknesses typical of components in microcircuits, these thicknesses may be appreciable when compared to the range of the nuclear product particles, such as the alpha particle produced upon capture of a neutron; the efficiency and even the useful operation of the device as a neutron detector can be compromised by an inappropriate choice of thickness, even for thickness in the range of typical components of microcircuits. The passivation layer for this purpose may be considered a typical component of a microcircuit. "The passivation layer 129 is typically an oxide, such as silicon dioxide" Column 4, line 1 and is an insulator. Assuming the thickness of the insulating layer 119 may be equivalent to the disclosed thickness of Hossain's passivation layer (col. 4, line 3), "from about 500 to 5000 angstroms and up", Hossain's specified thickness has no upper limit, and passivation layers may be hundreds of microns thick, much thicker than the range of a nuclear product (e.g., alpha) particle. Even at 5000 angstrom thickness, reductions in efficiency occur. Range of nuclear products (e.g., alpha) is not discussed. Hossain's teaching of insulator thickness, as inferred from passivation layer thickness, is incomplete and does not account for nuclear product (e.g., alphas) ranges. Thus, Hossain does not define or teach proximity in the matter of the insulating layer 119.

9. Hossain states that the insulating layer 119 "may" be formed. In the allowed case that the insulating layer 119 is not formed, then Hossain has not disclosed that a thereafter applied neutron-reactant material, which is chemically or electrically active (such as lithium metal) or electrically conductive, will impact the functioning of the memory cell and associated circuitry, and could render these non-functional. Also in the allowed case that the insulating layer 119 is not formed, then Hossain has not disclosed that the penetration of nuclear product (e.g., alpha) particles through material, such as the gate structure and conductors, may be insufficient for the nuclear product (e.g., alpha) particles to reach the memory cells with sufficient remaining energy to change the state of a memory cell.
10. Hossain provides scant guidance on the thickness of circuit structure layers. Hossain discloses a layered gate structure 109 with several components (Figure 1A), but does not disclose the thicknesses of the components, or their individual or combined effect on nuclear product (e.g., alpha) penetration. Hossain does not disclose the thickness of other components intervening between his neutron-reactant material and his memory cell, nor does he teach the undesirable attenuation by which those intervening components prevent nuclear product (e.g., alpha) particles from reaching the memory cells with sufficient energy remaining to be detectable, nor does he teach that sufficient thickness of the intervening components can render the device ineffective, inefficient or useless as a neutron detector.
11. Thus, Hossain does not define or teach proximity in relation to intervening circuit layers or material or components. Hossain discloses only the thickness of his neutron-reactant layer as being important for penetration of the emitted nuclear product (e.g., alpha) particles (Col. 3, Line 50). His teaching, then, is that only this thickness is to be considered in regard to

penetration of the nuclear product (e.g., alpha) particles. Hossain omits any teaching of the vital importance of other intervening materials in preventing nuclear product (e.g., alpha) particles from reaching the memory cells. The *thickness* of the neutron-reactant layer does not define or teach the *proximity* of the neutron-reactant layer to the memory cells. In short, Hossain teaches only the vaguest notion of how near the neutron-reactant material may be to the charge-sensitive region, and does not disclose how near it must be. This proximity or “near” is left undefined.

12. As a nuclear product (e.g., alpha) particle penetrates through material intervening between the neutron-reactant and the memory cell, it loses energy through attenuation as it goes. If the intervening material is sufficiently thick, the particle will not reach the memory cell. Even if the particle reaches the memory cell after passing through intervening material, the remaining energy deposited by the particle in a memory cell may be insufficient to change the state of the memory cell. Hossain has not taught the design principles whereby these undesirable outcomes may be prevented. Without this teaching the operation of a functional detector built from his instruction cannot be assured.
13. Hossain indicates that “other types of memory cells such as dynamic random access memory (DRAM) cells, static random access memory (SRAM) cells, or charge coupled devices (CCD) may be used with the present invention,” Col. 4, Line 14. However, the structure of some of these circuits is so complicated, involving so many structural layers, that the range of an alpha particle produced on the top of the layer is much smaller than the thickness of the circuit structure, and the alpha will never reach the memory cell below. Hossain’s placement of neutron-reactant layer will be ineffective in making a functioning neutron detector in such

cases. Hossain does not disclose teaching to recognize or avoid this situation. Hossain's meaning of "near" (claim 1) is insufficiently disclosed.

14. The examiner stated that Hossain discloses "10-Boron may range from about 80 to 100 percent of the total Boron concentration." The natural abundance of 10-Boron is about 20% of boron atoms. Isotopically enriched boron may be used to prepare BPSG to achieve the concentrations stated by Hossain. However, Hossain does not take note of the overall concentration of boron in BPSG. According to a scientific review article, "The boron and phosphorous contents of the silicate glasses vary depending on the application, typically being from 2 to 8 wt.%" ("CVD of SiO<sub>2</sub> and Related Materials: an Overview," Andrew R. Barron, ADVANCED MATERIALS FOR OPTICS AND ELECTRONICS, VOL 6. 101 - 114 (1996).) The concentration of Boron is therefore no more than 8 weight percent at best, even in a sample made of isotopically pure 10-Boron with no 11-Boron. Thus, the great majority of material in BPSG is merely another intervening attenuating material that depletes the energy of the nuclear product (e.g., alpha) particles, as mentioned above. Hossain does not teach the energy loss or attenuation of nuclear product (e.g., alpha) particles in the phosphorous, silicon, and oxygen (PSG) of the BPSG, and does not teach how the presence of this attenuation places further requirements that any additional attenuation from other intervening materials be small. Hossain does not teach or disclose the tightened requirement for close proximity due to attenuation in the PSG.

15. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made

are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the patent application or any patent issuing thereon.

Date: 17 April 2006 Signature: Robert R. Whitlock

Robert R. Whitlock